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First record of non-native platyfish, *Xiphophorus maculatus* (Günther, 1866) (Cyprinodontiformes, Poeciliidae), in the Jaguaribe River basin, northeastern Brazil

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Abstract

We provide the first record of *Xiphophorus maculatus* (Günther, 1866) in a river basin in northeastern Brazil. Specimens were collected in the Jaguaribe River basin, João Pessoa, Paraíba state, Brazil. Two hundred eighty-one specimens, corresponding to 143 males and 138 females of *X. maculatus*, were collected at nine sites along the basin, from 2017 to 2019. Specimens total length ranged from 17.5 to 26.6 mm in males and from 11.7 to 32.7 mm in females. Introduction of non-native species greatly threatens the biological diversity worldwide. When introduced into a new habitat, *X. maculatus* usually decreases microcrustacean, macroinvertebrate and native fish populations.

Keywords

Competition, freshwater fish, invasive species, ornamental fish.

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Introduction

Poeciliidae is the second most species-rich family of the order Cyprinodontiformes, currently corresponding to 276 valid species (Fricke et al. 2020). Poeciliid fishes occur in the Americas (North America to northern Argentina) and Africa (Congo basin, African rift lakes, Dar es Salaam, and Madagascar) (Lucinda 2003; Fricke et al. 2020). The subfamily Poeciliinae comprises species distributed in 28 genera (Fricke et al. 2020). *Xiphophorus* Heckel, 1848 is a Poeciliinae genus composed of 26 valid species (Fricke et al. 2020), with 20 recorded in the Atlantic versant of the Sierra Madre, Mexico, and adjacent areas in Central America (Kallman et al. 2004). Members of Poeciliinae are characterized by a copulatory organ, the gonopodium, which develops from modifications of the 3rd, 4th and 5th anal-fin rays (Parenti 1981; Lucinda and Reis 2005).

Xiphophorus maculatus (Günther, 1866) is one of the most widely distributed species of the genus in Central

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America, being recorded from Jamapa River (near Veracruz, Mexico) to Guatemala (Kallman et al. 2004). Individuals exhibit a variety of chromatophores, such as micromelanophores, xanthophors and iridiophores, which store and synthesize pigments (Kallman 1975). This feature might have drawn the attention of aquarists since this species is bred for ornamental purposes in several countries (Nico and Fuller 2009). About twenty years ago it was considered the third most imported ornamental species in the United States (Chapman et al. 1997). *Xiphophorus maculatus* is one of the most common species in fishkeeping worldwide, including Brazil (Magalhães and Jacobi 2017; Sanders et al. 2018; Froese and Pauly 2020).

Fishkeeping has been one of the main routes for ornamental fishes invading Brazilian rivers (Magalhães et al. 2009). A species is introduced when it breaks the first barrier, that is, the geographical one, usually due to intentional or accidental human intervention. It happens when individuals are transferred from its native range to another habitat in which the species was not occurring before. To be an invasive, the species needs to establish by producing fertile offspring that survive in the new environment. After establishment, the invasive species widens its distribution in the new habitat and threatens the native biodiversity (Lodge 1993; Moyle and Light 1996; Lymbery et al. 2014). Introduction of non-native species greatly threatens the biological diversity worldwide (Vitule 2009; Levis et al. 2013; Lima-Junior et al. 2018). Invasive species can compete with native ones for food and space and they can also carry new diseases and pathogens to the habitat. Those impacts can synergistically decrease native populations and even lead some to extinction (Magalhães et al. 2009).

Poeciliidae species exhibit high invasive potential. When Poeciliidae representatives are introduced into a new habitat and become invasive, they decrease microcrustacean (zooplankton) and macroinvertebrate (Odonata) populations by feeding on them. Regarding native fishes, impacts are associated to competition for space and food as well as predation (Magalhães et al. 2009; Stockwell and Henkanaththegedara 2011; Magalhães and Jacobi 2017). Here we provide the first record of the Poeciliidae *Xiphophorus maculatus* (Fig. 1) in a river basin in northeastern Brazil, which represents a potential threat to native species.

Methods

Study area. The Jaguaribe River is located within the Atlantic Forest biome (between 07°03′21.0″S, 034°50′35.4″W and 07°10′06.1″S, 034°54′10.7″W). Its main course is about 21 km long, crossing João Pessoa municipality and heading for the Atlantic Ocean in Paraíba state, Brazil. The Jaguaribe River basin encompasses about 11.6 km^2 and its boundaries are the Atlantic Ocean at east, the Marés River at west, the Paraíba do Norte River basin at north and the Cuiá River basin at south (Dieb and Martins 2017).

Fieldwork. The fieldwork consisted of three collecting expeditions and nine collecting points in the Jaguaribe River basin: on October 18, 2017, with three sampling points (two in artificial stream channel Bessa Canal I and one in channel Bessa Canal II); on August 27, 2018, to sample a point at the artificial stream channel Bessa Canal II; and a third one between October 6 and 29, 2019, where six more points, at artificial stream channel Bessa Canal II, were sampled.

Fieldwork was approved by the National System of Biodiversity Information (SISBIO; permit #56416-1/2016). Sampling was performed using manual trawls 4 m length, 2 m high and 5 mm mesh and dip net (5 mm mesh). Individuals were anesthetized in eugenol, then fixed in 10% formalin and transferred to ethanol 70 °GL after eight days (Malabarba and Reis 1987).

Lab work. Images of live specimens were taken inside an aquarium using a Canon PowerShot SX60 HS camera. A photo of the gonopodium was taken from specimens preserved in alcohol, without any treatment.

Specimens were identified at the Laboratório de Ecologia Aquática of the Universidade Estadual da Paraíba (LEAQ/UEPB) according to Rosen (1960, 1979) and then deposited in the Ichthyological Collection of the Departamento de Sistemática e Ecologia of the Universidade Federal da Paraíba (CIUFPB). Counts followed Hubbs and Lagler (2006).

Results

A total of 281 specimens of *Xiphophorus maculatus* were collected at nine sites along the Jaguaribe River basin (Fig. 2), corresponding to 143 males and 138 females. In October 2017, 16 specimens were collected, six at the Bessa Canal I affluent and ten at the Bessa Canal II affluent. In August 2018, 22 specimens were collected at the Bessa Canal II affluent, and in October 2019, 243 specimens were collected. Total length ranged from 7.1 to 26.6 mm in males and from 11.7 to 37.3 mm in females. It was not found close to the Jaguaribe River headwaters or in its main tributary, the Timbo River.

Xiphophorus maculatus is syntopic with three native species, *Astyanax bimaculatus* (Linnaeus, 1758), *Poecilia vivipara* Bloch & Schneider, 1801 and *Eleotris pisonis* (Gmelin, 1789), and two other exotic species, *Oreochromis niloticus* (Linnaeus, 1758) and *Poecilia reticulata* Peters, 1859.

Material examined. All from Brazil, Paraíba State, João Pessoa, Jaguaribe River basin: CIUFPB 11322, 1 specimen, 12.6 mm standard length (SL), artificial stream channel Bessa Canal I (07°05′20″S, 034°50′44″W), T.P.A. Ramos et al., 18 Oct 2017; CIUFPB 11323, 5 specimens, 13.6–34.6 mm SL, artificial stream channel Bessa Canal I (07°05′15″S, 034°50′29″W), T.P.A. Ramos et al., 18 Oct

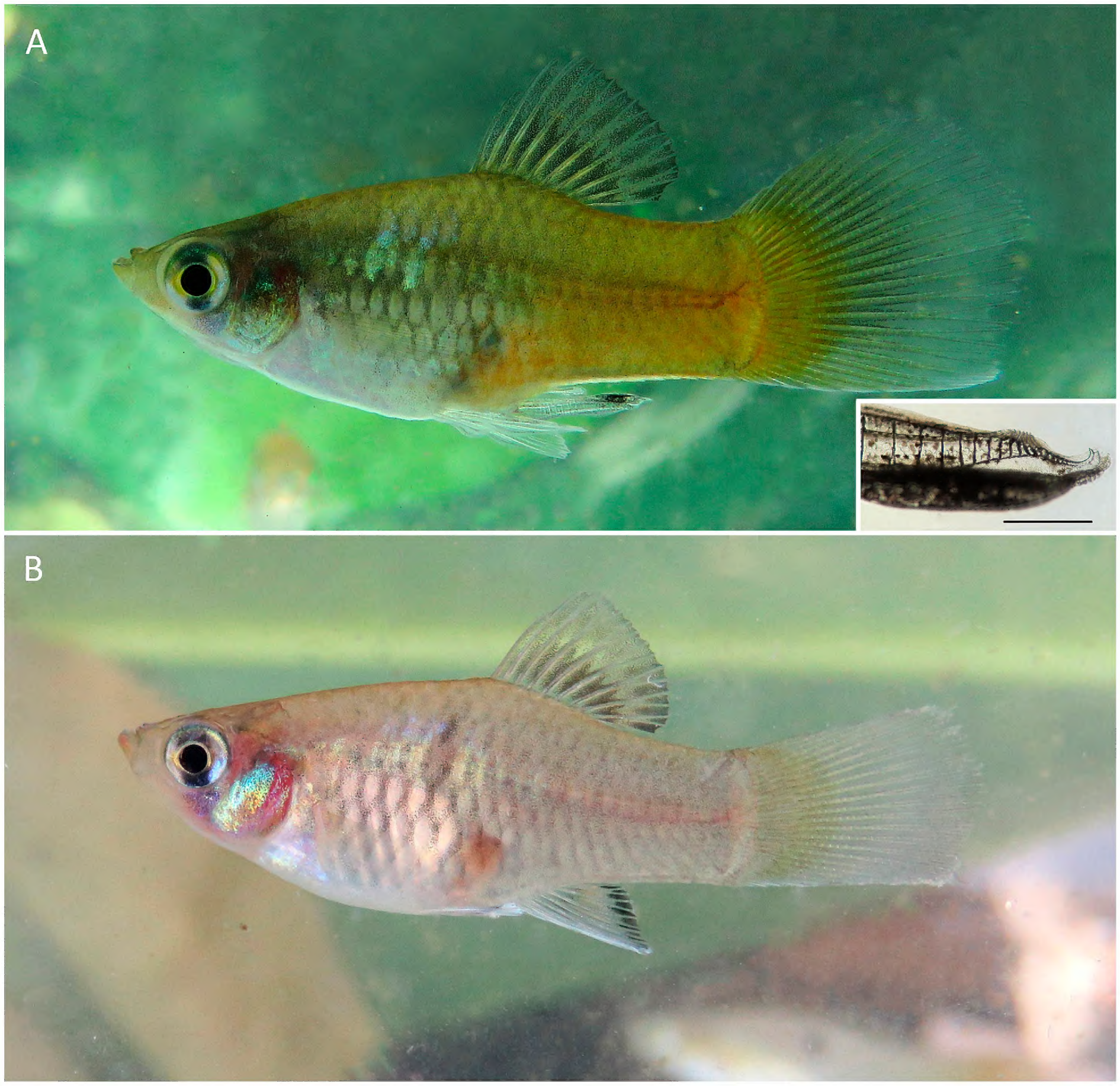

Figure 1. *Xiphophorus maculatus*. **A.** Adult male, 24.4 mm SL, and tip of the modified anal-fin (gonopodium). **B.** Adult female, 28.2 mm SL, UFPB 11618. Scale bar: 1 mm.

2017; CIUFPB 11324, 10 specimens, 14.7–21.2 mm SL, artificial stream channel Bessa Canal II (07°04′51″S, 034°50′46″W), T.P.A. Ramos et al., 18 Oct 2017; CIUFPB 11618, 22 specimens, 12.1–37.3 mm SL, artificial stream channel Bessa Canal II (07°04′51.5″S, 034°50′46.0″W), T.P.A. Ramos et al., 27 Aug 2018; CIUFPB 11977, 15 specimens, 7.1–29.4 mm SL, artificial stream channel Bessa Canal II (07°04′51″S, 034°50′44″W), G.B.M. Beltrão et al., 06 Oct 2019; CIUFPB 11981, 52 specimens, 13.1–27.8 mm SL, artificial stream channel Bessa Canal II (07°04′52″S, 034°50′40″W), G.B.M. Beltrão et al., 08 Oct 2019; CIUFPB 11988, 27 specimens, 14.1–34.6 mm SL, artificial stream channel Bessa Canal II (07°04′51″S, 034°50′37″W), G.B.M. Beltrão et al., 14 Oct 2019; CIUFPB 11991, 124 specimens, 7.1–34.4 mm SL, artificial stream channel Bessa Canal II (07°04′51″S 034°50′34″W), G.B.M. Beltrão et al., 15 Oct 2019; CIUFPB 11995, 4 specimens, 14.5–20.1 mm SL, artificial stream channel Bessa Canal II (07° =04′48″S, 034°50′20″W), G.B.M. Beltrão et al., 29 Oct 2019; CIUFPB 11999, 21 specimens, 11.3–23.5 mm SL, artificial stream channel Bessa Canal II (07°04′45″S, 034° 50′13″W), G.B.M. Beltrão et al., 29 Oct 2019.

Identification. Specimens were taxonomically identified following Rosen (1960). *Xiphophorus maculatus* is characterized by (i) a reticular pigment developing into an indistinct netlike pattern above and below mid-side; (ii) lack of horizontal zigzag stripe at mid-side; (iii) dorsal fin rays 7–11, usually nine or ten; and (iv) scales in lateral series 22–25, usually 23 or 24.

Discussion

The non-native species *Xiphophorus maculatus* is recorded for the first time in northeastern Brazil, in nine

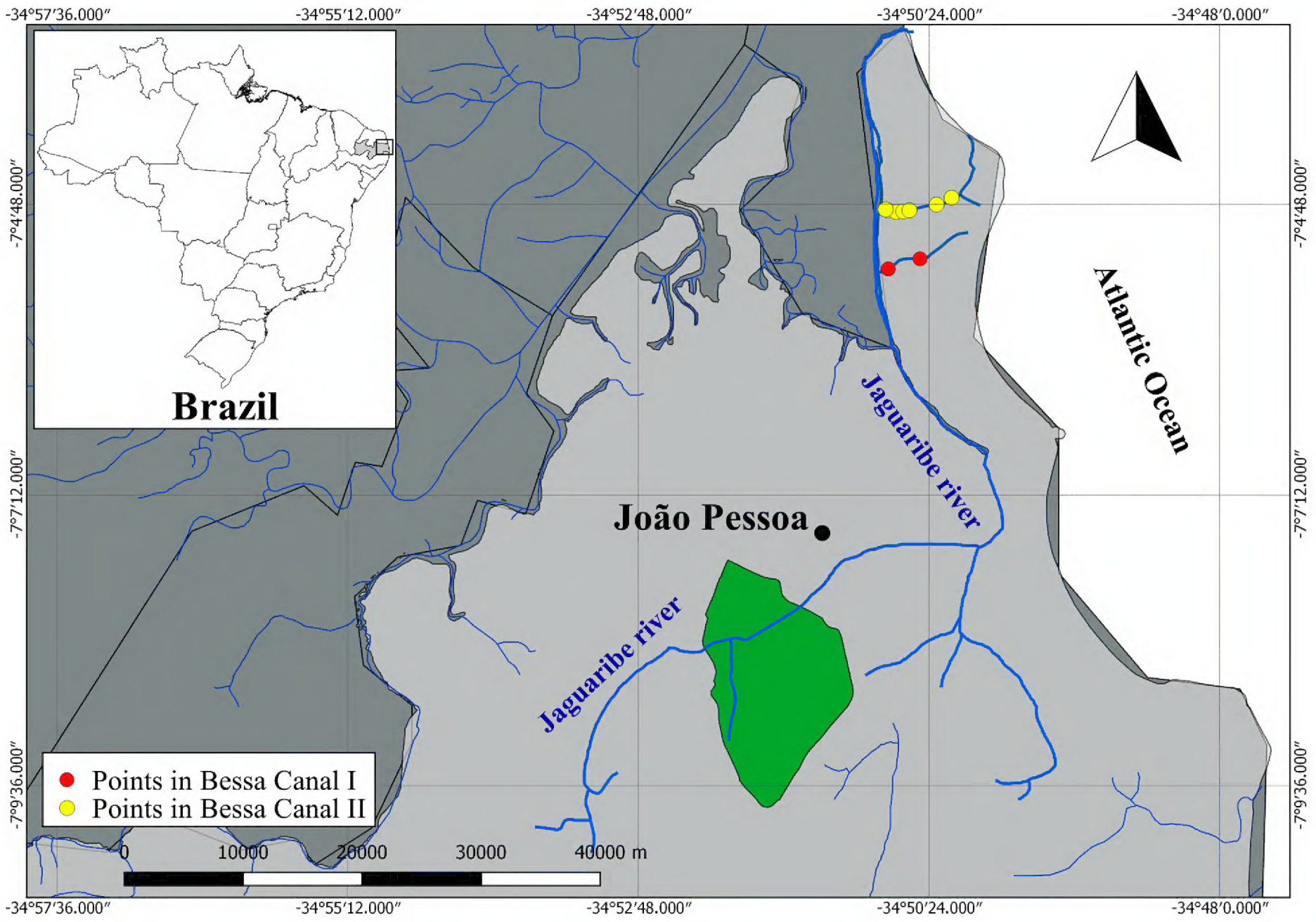

Figure 2. Records of the non-native *Xiphophorus maculatus* in the Jaguaribe River basin, municipality of João Pessoa, Paraíba state, north-eastern Brazil.

sampling sites at the Jaguaribe River basin. The species probably reached the basin due to aquarium trade. Dumping is a common practice of releasing specimens into natural watersheds. *Xiphophorus maculatus* exhibits a high degree of invasiveness and it has been recorded in several other drainages worldwide (Espinosa-Pérez et al. 1993; Bomford and Glover 2004; Kottelat 2013; Meyer 2015; Fricke et al. 2018; Robins et al. 2018).

As many other poeciliid species, some species of *Xiphophorus* are highly appreciated by aquarists. In Brazil, the most common poeciliid species in aquarium probably are: *Poecilia reticulata*, *P. sphenops* Valenciennes, 1846, *P. velifera* (Regan, 1914), and *P. latipinna* (Lesueur, 1821), *Xiphophorus helleri* Heckel, 1848, and *X. maculatus* (Günther, 1866) (Brito et al. 2013). Aquarists have introduced several species all over the world. Many ornamental fish breeders usually release specimens into rivers close to their residences when they are not willing to keep the fishes anymore (Magalhães et al. 2009; Levis et al. 2013). Furthermore, Poeciliidae species such as *Poecilia reticulata*, *P. sarrafae* Bragança & Costa, 2011 and *P. vivipara* are widely used to control insects such as *Aedes aegypti* (Levis et al., 2013) because they feed on mosquito larvae. Consequently, poeciliids have been introduced in several countries and many of them found suitable conditions to become an invasive species (Brito et al. 2013).

Some sites of the Jaguaribe River basin, in which *Xiphophorus maculatus* was collected, are facing a faunal impoverishment due to possible local extinctions that result from widespread environmental degradation consisting in water pollution and changes in its drainage area (Alves et al. 2009). Degraded environments are susceptible to the establishment of non-native species (Lonsdale 1999; Lockwood et al. 2005). Poeciliidae species such as *X. maculatus* are usually capable of surviving in polluted urban waters (Lim and Ng 1990; Tan et al. 2020) such as the channels in João Pessoa, Paraíba, in which the species was found. Therefore, *X. maculatus* could have been able to colonize the Jaguaribe basin due to its known environmental degradation.

Ramos et al. (2017) recorded 18 freshwater fish species in the Jaguaribe River basin, out of which two were non-native: the tilapia, *Oreochromis niloticus*, and the barrigudinho, *Poecilia reticulata*. Introduced species have been the second biggest threat to native biodiversity worldwide (Lima-Junior et al. 2018; Reid et al. 2019). *Xiphophorus maculatus* was recorded syntopic with *Poecilia vivipara*, a native species in the Jaguaribe basin. These species may be competing since they share some similarities, such as the feeding habits on plant material and aquatic invertebrates. Besides food, these species can also compete for shelters and breeding sites (Menezes et al. 2007; Maddern et al. 2011; Lawal et al. 2012). We also collected *O. niloticus* and *P. reticulata* together with *X. maculatus*. Therefore, these three species may be

decreasing the richness of the native fauna, as mentioned by Alves et al. (2009), since introduced species usually induce ecological problems over native species, such as competition and predation (Kolar and Lodge 2001; Lymbery et al. 2014).

Xyphophorus maculatus is another environmental disturbance in the Jaguaribe River basin, which is already highly degraded. This new record deserves attention because when Poeciliidae species such as *X. maculatus* are introduced into a new habitat, the populations of microcrustaceans, macroinvertebrates and native fish decline significantly. Therefore, we encourage further studies to assess the degree of invasibility of this species in the basin.

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Authors' Contributions

TPAR and YGPCR performed field samplings, taxonomical identifications and paper writing; SYLC and JELB assisted the paper writing and review.

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